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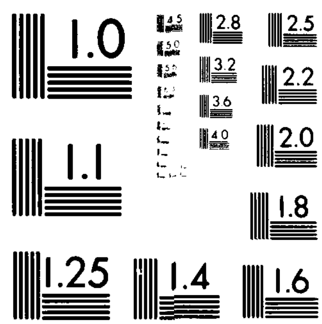

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EVALUATION OF INSTRUMENTATION

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31 January 1979

Final Report for Period 3 October 1977–2 October 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains a description of the recent activities of JAYCOR in the DNA program to evaluate instrumentation used in nuclear underground tests and other nuclear simulator experiments. Primarily this activity consisted of Dr. Larry Scott reviewing the instrumentation used by experimenters and recommending improvements. This activity is aimed at improving the quality of data from simulator and UGT experiments. Detailed technical discussions are found in other reports; an overview is presented here.

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1. INTRODUCTION

The purpose of this report is to document JAYCOR's activities during the past year on the DNA program to evaluate the instrumentation used on underground nuclear testing and other nuclear simulators. The main effort of this evaluation is in the area of grounding and shielding, with emphasis on the underground nuclear test environments.

The greatest activity this past year centered around the Diablo Hawk event, which occurred in September 1978. In addition, JAYCOR participated in the high-explosives test program, Miser's Bluff, which was a two-phase experiment. Phase 1 occurred in June, Phase 2 in August 1978. Again, grounding and shielding were the primary contributions that JAYCOR provided these programs.

In addition to these two major experiments, participation was required in a large number of meetings and on proposal review boards, primarily the proposal review activity for the upcoming underground nuclear test, Miner's Iron. That activity is still in progress.

There were two documentation efforts in addition to these grounding and shielding programs. The principal one was documentation of the latchup review program for DNA/RAEV. The latchup report has been submitted for publication. Additional documentation was generated during this time period on the Hybla Gold event, an underground nuclear test (DNA 4555F, September 1977). That activity was in support of the Miner's Iron grounding and shielding proposals. In each of these activity areas, JAYCOR's contribution consisted primarily of the author participating in the meetings, the experiment review, and direct interactions with the experimenters to evaluate and recommend improvements to their instrumentation techniques.

The following sections contain a discussion of each of the abovementioned project areas — the Diablo Hawk underground nuclear test, the Miser's Bluff high-explosives testing, a brief list of the principal meetings during the past year, a descriptive paragraph or two regarding the latchup report completed for DNA/RAEV, and an indication of the direction in which this contractual effort is going in the present year.

2. UNDERGROUND NUCLEAR TEST — DIABLO HAWK, SEPTEMBER 1978

Approximately 2-1/2 years were spent on preparation time prior to the Diablo Hawk event; several delays occurred in the scheduled readiness date. Of necessity, the interruptions in the preparation activities that resulted from those schedule slippages caused some intermittent work loads at the facilities of experimenters that were working on these experiments. For about 1-1/2 years prior to shot time, the author was involved with evaluations of various experimenters' instrumentation setups. The level of participation consisted of traveling to the various experimenters' facilities, such as Lawrence Livermore Laboratories or General Electric Company, with the technical director, Captain Leslie McKee, and visiting with the various experimenters, identifying any problem areas in their instrumentation.

Several of these trips identified problems of such magnitude that the experiments would not have been useful had the recommended changes in instrumentation not been performed. Unfortunately, not all the experimenters responded to the recommendations for changes in their instrumentation. For example, Lawrence Livermore Labs, in spite of the large costs involved in fielding their experiments, obtained no data, as predicted by this review procedure.

The Diablo Hawk event occurred without the benefit of a detailed instrumentation review. Captain McKee, in his capacity as technical director, did not convene such a committee, which has been done in the past on other events. Several experiments suffered loss of data due to inadequate preparation or to a lack of awareness of the environmental effects on their instrumentation. For example, in the Physics International propellant studies, the location of an active filter in the alcove area, which used an operational amplifier with relatively large capacitance in the feedback path, was a bad choice. These active filters were unable to recover from the gamma-induced photocurrents in the cables in time to record all of the data that was sought by PI. The result was that a large time portion, more than 100 msec in some channels,

was lost. It is a well documented fact that active filters, with their associated operational amplifiers of the high-gain variety, are quite sensitive to low levels of radiation (1 or 2 rad) that are frequently encountered in the alcove environment. So it was quite clear that the placement of such a filter in the alcove would precipitate this kind of response, and the recommendation would have been for PI to do a flash x-ray type of exposure on those amplifiers (i.e., the filters) prior to fielding the experiment. The overload recovery characteristics are also a necessary study area for these circuits. Because the instrumentation evaluation review committee was not convened for that event, no such recommendations were provided.

The principal areas of impact on Diablo Hawk in the instrumentation evaluation program were to the Lockheed C4 tank experiment, where considerable effort was put into identifying an appropriate grounding and shielding scheme. Due to the extreme complexities of that experiment and the insufficient size of the tank, the compromises in performing that experiment are reflected in the compromised data that was obtained. Also in that particular experiment, the LMSC fielding crew failed to take into consideration the electromagnetic interference environment in the alcove, with the result that a logic reset pulse occurred to their sequencer in the alcove and reset the entire flight control computer shortly (3 msec) after zero time, and the data obtained in the experiment from the flight control computer was compromised due to this noise pulse. This noise reset pulse was identified after the test by laboratory experiments as being about 1 volt or more and 100 nsec in duration. Such noise signals are quite common in the alcove environment; in fact, noise pulses can exceed those limits quite easily.

The Kaman Sciences experiments were also found deficient in their grounding and shielding approach early enough in the experiment fielding that a reconfiguration of those experiments was requested and completed. Kaman Sciences obtained very clear, highly satisfactory data from those experiments.

A grounding procedure was recommended for the structures drift, particularly for the cables coming out of the zero room, identified as the device cables. It was anticipated that there would be very large sheath currents on the device cables due to their proximity to the zero room at event time.

By grounding the shields of those device cables prior to their entering the cable bundle or the cable plant of the structures experiments, it was predicated that the structures cable plant would not experience typical cable plant ringing or noise cross-talk interference problems observed in past experiments. There was some degree of mechanical difficulty in realizing the grounding of those cable shields due to the lack of accessibility of a good grounding point at the appropriate location in the drift. The resulting mechanical configuration consisted of stripping the cable jackets back and clamping the exposed cable shields to the unistrut bars that were welded to rock bolts in the ceiling of the structures drift. This provided a solid low-frequency ground point to lead off any currents on those cable shields. A waterproof box was built around this structure and filled with a coal tar compound. Because those cables were also buried in concrete between the zero room and the structures (i.e., in the stemming), a lot of the high-frequency noise induced on the cable shields up near the zero room would have been removed from the cable shields in that grouted area because of the rather high attenuation of high-frequency signals on the shields of the cables passing through the grout. The attenuation is several tens of decibels per meter, above 1 MHz, in the typical grout used in an underground test. Reports being submitted to DNA identify the detailed nature of the data base obtained in the Diablo Hawk event, and the information is not repeated here.

In conclusion, the Diablo Hawk event benefitted from the instrumentation evaluation contractual effort by an improvement in the quality of the data that was obtained and by an increase in the percentage return of the channels of instrumentation fielded for that event. Approximately 87% of the channels yielded useful data, a rather high number considering the large total number of channels fielded for the event and the complexity of the experiments involved. Several thousand channels of data were recorded for Diablo Hawk, the largest of any underground nuclear test fielded to date.

3. HIGH-EXPLOSIVES TEST — MISER'S BLUFF

In the summer of 1978, the Miser's Bluff event occurred near Lake Havasu City, Arizona. The selection of the test site and the review of experiments occurred without participation of the instrumentation evaluation group. The author became involved in the activity in the late spring of 1978, when the instrumentation engineers at DNA Field Command requested support in responding to the criticism of RDA, a DNA consulting house, that electromagnetic pulse fields generated by high-explosives detonations were of sufficient strength to produce noise pulses in the instrumentation channels that would mask the signal data. DNA based this assumption on an earlier, very inexpensive experiment performed by one of the RDA staff, which consisted of a small radio and tape recorder located several miles away from the point of detonation of a high-explosives test. There was a period (several hundred milliseconds) of noise multiple-pulse-type pickup by the radio, which was recorded on the tape recorder. Unfortunately, the sensitivity of the radio in terms of the field strengths being recorded at the time was not quantified. However, the ten-dollar pocket transistor radio that was used typically has a sensitivity of a few microvolts per meter and an automatic gain control (AGC) circuit. Shielding requirements to provide adequate protection of the data channels were proposed to the fielding staff.

A literature search indicated that some electromagnetic pulse fields may be generated by such a high-explosives event due to the nonsymmetrical fireball in an explosion at the earth's surface. The predominantly vertical electric field created by such a nonsymmetrical fireball should produce a vertical electric field which would then propagate with the typical 1/r losses along the experimental facility. At Miser's Bluff, precautions were taken to ground the shields of all cables used in the instrumentation channels at the junction boxes and at the point of entry to the instrumentation trailers, which were located approximately 1 to 1-1/2 miles from zero point. In the riverbed that was used as a test site, the grounds that were available were manufactured by using a 10-foot copper rod driven into

ground in hopes of touching the water table or getting some portion of the rod into the ground water. Measurements made on such ground rods indicated approximately 10 ohms to ground, which was adequate for the type of protection that is sought in this sort of test.

Using good electromagnetic interference protective procedures in the high-explosives test environment resulted in the grounded cable shields being terminated at the trailer shell before the cables penetrated the trailer. There was an attempt to remove any additional wires that went into the trailer so that no inadvertant antennas might be coupling energy into the recording environment. Also, the cables that went from the junction boxes to the sensors out near the point of detonation were also grounded, where possible, although not all the experimenters opted to comply with such grounding recommendations.

Prior to event time, a dry run was performed in which a dummy detonator or detonators were used and the actual detonator-type electrical pulses were transmitted along their specific cables. In place of the high-explosives detonators, a sugar-cube detonator was fielded which provided a good simulation of the current and voltage pulse that occurs during actual detonation.

The noise signals received on the instrumentation channels during the dry run were exact overlays of the noise signals picked up by those same channels at the time of the high-explosives detonations, which leads to the conclusion that the noise pulses observed at Miser's Bluff were in fact due to interference and cross-talk from the power pulses delivering energy to the detonators. These power pulses are in the range of a few kilovolts and several hundred amperes, lasting for a few tens of milliseconds. That kind of energy pulsing along the cables in the cable plant over the large linear cable runs in a high-explosives test provides the cross-talk required to explain the observed noise pulses in the instrumentation channels. The noise pulses on Miser's Bluff in the worst case were a few tenths of a volt, lasting for a few hundred microseconds. Some accelerometer data and strain gage data were in the millivolt range, although most had greater durations. The frequencies involved were characteristic of the roughly 5,000 feet of cable laid out on the surface of the earth.

The measurements made of bulk cable currents in the instrumentation channel cables and the attempted free-field electric field measurements

during the event were the result of the instrumentation evaluation activities on that event. Noel Gantic, DNA Field Command, was the instrumentation engineer on that event and had the responsibility for fielding those measurements. The recorded data indicate that the EMP signal from the high explosives is not significant.

The Phase 2 portion of Miser's Bluff was a detonation of 720,000 pounds. There were six stacks of amphenol explosives, and if that magnitude of high-explosive detonation did not produce significant EMP, it is quite likely that subsequent tests of similar magnitude or smaller will also not produce a significant EMP type of noise pulse on the instrumentation channels.

4. MEETINGS

Location	Date	Subject
DNA Field Command	Jan. 5-6	Hybla Gold D+60 preliminary data presentation and review
SAI, La Jolla	Feb. 1	Hybla Gold report preparation
KSC, Colorado Springs	Feb. 22	Diablo Hawk discussions
ETI, Santa Barbara	Feb. 23	"
CSDL, Boston	Feb. 28	"
G.E., Philadelphia	Mar. 1	"
LASL, Los Alamos	Mar. 2	"
DNA Field Command	Mar. 3	"
LMSC, Sunnyvale	Mar. 6-7	"
LLL, Livermore	Mar. 8	"
NVO, Las Vegas	Mar. 14	POM, Diablo Hawk
JAYCOR	Mar. 28	Dr. Peek's visit
TRW, Redondo Beach	Apr. 11	Diablo Hawk discussions with Paul Chivington
N-Tunnel	Apr. 20-21	Test bed preparation, Diablo Hawk
DNA Headquarters	May 22	Diablo Hawk discussions
NRL, Washington	May 23	Latchup meeting (Al Wolicki)
LMSC, Sunnyvale	May 31, June 1-2	Diablo Hawk discussions
DNA Field Command	June 13-15	"
Lake Havasu City, AZ	June 19-20	Miser's Bluff
N-Tunnel	June 20-21	Diablo Hawk discussions
LMSC, Sunnyvale	June 22	"
N-Tunnel	Aug. 14-17	"
Lak Havasu City, AZ	Aug. 29-30	Miser's Bluff
N-Tunnel	Aug. 31	Diablo Hawk
N-Tunnel	Sep. 11-13	Diablo Hawk
DNA Field Command	Sep. 27-28	Diablo Hawk
DNA Field Command	Oct. 25-27	Miner's Iron proposal review

Location	Date	Subject
LMSC, Sunnyvale	Oct. 30-31, Nov. 1-2	Diablo Hawk review
RDA, Marina del Rey	Nov. 3-4	Latchup meeting
DNA Field Command	Nov. 14-16	Diablo Hawk D+60
DNA Field Command	Dec. 4-7	Miner's Iron review

There are a few meetings left out, but those indicated will communicate the travel activity level required during this last year.

5. LATCHUP REPORT FOR DNA/RAEV

Latchup in integrated circuits has been a serious problem area in the study of radiation effects since the advent of integrated circuits in military systems — i.e., about the last decade. Latchup is a very difficult problem to deal with since only a small percentage of the total population of parts exhibit this particular failure mechanism. Second- or third-order variations in the manufacturing processes result in conditions being such that latchup can occur.

In the last decade, every military system that has a radiation environment specified has dealt with latchup problems. Each system has dealt with the problem in a different way. Some ways obviously are more efficient and cost-effective than others, and it was the purpose of this study to document the various tools available for working the latchup problem and to give some examples of various systems that have used the different tools and experienced the different risk factors involved in those tools.

A meeting was called at DNA to discuss the latchup situation. Members of the latchup community provided a discussion of the state of the art for latchup control in missile, satellite, and avionics systems where such a failure mechanism is most significant. The resulting document was prepared, reviewed by the participants of the latchup community meeting, revised as per their input, and submitted to DNA for subsequent publication (pending at this time). Inasmuch as that document has been submitted to DNA and is available there, it would be redundant to discuss it any further at this time.

6. CONCLUSIONS

In the past year, as is apparent from the activities described here, the author has been extremely busy in providing support to the contracted experimenters of DNA as well as providing technical support to the DNA Field Command staff. The continuity provided by this contractual effort — i.e., a year-after-year instrumentation evaluation and support — is most beneficial to DNA as demonstrated by this effort and others in the DNA advisory capacity over the last several years. In the immediate future, preparations for the Miner's Iron event, the Huron King event, and above-ground nuclear simulator facility tests are all benefitting from the grounding and shielding philosophy that has been developed over the last several years of this instrumentation evaluation contractual effort.

The peculiarities of the nuclear simulation test program have precipitated peculiar grounding and shielding requirements for those activities. The extremely high energies generated during these events produce noise sources in the instrumentation cables, recording equipment, or signal conditioning equipment located in the frontal areas of the experimental test bed that are peculiar to this type of experimentation. The transient radiation effects on electronics, or TREE-type, response of these instrumentation channels requires a very careful design and development of channels to enable the experimental data to be properly recorded without distortion due to noise. The electromagnetic interference techniques used in standard instrumentation are a good place to start in developing a grounding and shielding plan for these simulated nuclear events. Such techniques are being expanded for the upcoming DNA-sponsored experiments.

Not only is the author working closely with DNA Field Command and the experimenters on those events, but his experience gained in field work is also being used in the proposal evaluation committee of DNA, particularly for Miner's Iron. Methods are being developed to impose grounding and shielding considerations on the nuclear test planning activities, both at the individual experimenter level and at the staff level where the test bed is considered as a system.

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